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Name of Design: Humidifier Using Hollow Fibers

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Specification

1. Name of Design
Humidifier Using Hollow Fibers

2. Utility Model Claims
A humidifier using hollow fibers and characterized by a construction whereby a hollow fiber bundle (7) of multiple bundled hollow fibers (6) having moisture permeability is contained in a sealed container (5) having end apertures (1), (2) and a central portion aperture (3), forming a region (11) that includes said end aperture (1), a region (12) that includes said end aperture (2), and a region (13) that includes said central portion aperture (3), these regions being isolated from each other with sealing members (8), with water or an aqueous solution filling the region that includes said central portion aperture and a gas flowing from said end aperture (1) toward aperture (2).

3. Detailed Explanation of the Design
(Industrial Application Field)
The present design pertains to a humidifier that incorporates hollow fibers having moisture permeability.

(Prior Art)
Conventionally various humidification methods whereby a gas (primarily, air) is humidified have been proposed. Generally a bubbling method whereby a gas is sprayed in a sealed container containing water or an aqueous solution in the liquid phase is used. In addition, methods such as one whereby a flow of gas is brought into contact with the surface of filter paper or gauze can be used.

(Problem to be Solved by the Design)
However, with the former method there is a problem in that there is a risk that the airborne water droplets generated when the gas bubbles burst will be taken into the gas flow, so the size of the gas-phase space above the surface of the liquid must be enlarged or a baffle plate must be provided at the gas flow extraction port, and thus the device becomes larger and more complicated. Furthermore, with the latter method the filter paper or gauze must be anchored, which complicates the structure.

(Means to Solve the Problem)
Accordingly, the objective of the present design is to provide a compact humidifier having a simple configuration. In other words, the present design is a humidifier using hollow fibers and characterized by a construction whereby a hollow fiber bundle (7) of multiple bundled hollow fibers (6) having moisture permeability is contained in a sealed container (5) having end apertures (1), (2) and a central portion aperture (3), forming a region (11) that includes said end aperture (1), a region (12) that includes said end aperture (2), and a region (13) that includes said central portion aperture (3), these regions being isolated from each other with sealing members (8), with water or an aqueous solution filling the region that includes said central portion aperture and a gas flowing from said end aperture (1) toward aperture (2).

In the implementation of the present design, hollow fibers comprised of a polymer material such as cellulose, cellulose acetate, ethylene vinyl alcohol copolymer, polymethyl methacrylate, polyethylene, polypropylene, polysulfone, and silicon can be used as the hollow fibers having moisture permeability.

When the hollow fibers are comprised of a hydrophilic polymer and when the water makes contact with one surface of the hollow fibers, it immediately begins to permeate into the cavity walls and rapidly reaches the surface on the opposite side, forming a gas-liquid boundary, and evaporating into and humidifying the gas. With porous hollow fibers comprised of a hydrophilic core material, the permeation rate for the water increases remarkably, so even if the evaporation rate for the water at the gas-liquid

boundary increases it is immediately replenished with new water, and thus high humidification efficiency can be maintained.

However, with hydrophilic porous hollow fibers comprised of, for example, cellulose, cellulose acetate, polyamide, polyimide, polyvinyl alcohol, ethylene vinyl alcohol copolymer, polycarbonate, polyacrylonitrile, or polymethyl methacrylate, when the porosity (percentage of holes) is high the water flows through the cavity walls and water droplets form in the gas flow, obstructing the flow of gas. Therefore, when hydrophilic porous hollow fibers are used, low-permeability hollow fibers with a permeability of not more than 400 ml/mm $Hg{\cdot}m^3{\cdot}hr$ and preferably of not less than 1 and not more than ml/mm $Hg{\cdot}m^3{\cdot}hr$ must be used. With the present design the porous hollow fibers used are ones for which a porous structure in the cavity walls has been confirmed with an electron microscope, or for which the permeation of substances with a diameter of 10 Å or greater has been confirmed by a publicly known method for measuring the permeation of substances.

For the measurement of permeability, pressurized water was supplied from one surface of the hollow fibers in a 25°C environment, the amount of water (ml) permeating to the surface on the other side was measured, and was removed with a unit time (hr), unit pressure (mmHg), and unit inner surface area (m^2). Furthermore, when the hollow fibers are comprised of a silicon series hydrophobic polymer such as polydimethylsiloxane, for example, the water supplied to the one surface of the hollow fibers dissolves in the molecular state in the polymer phase and diffuses, quickly reaching the surface on the other side, and diffusing into and humidifying the flow of gas. When porous hollow fibers comprised of a hydrophobic polymer such as polyethylene, polypropylene, Teflon, or polysulfone are used the water vapor in the in the porous substance diffuses rapidly, so the humidification can occur more efficiently than when silicon series hollow fibers are used. It is suitable for the pores of these porous hollow fibers to have a short axis of not more than 10 μ, and preferably not more than 0.5 μ. Of these, porous hollow fibers comprised of a hydrophobic polymer have a high permeation rate and can be used advantageously. Hollow fibers of this type preferably have a size of approximately 200/180 – 500/450 μ (outer diameter/inner diameter), and an average pore size of approximately 0.1 – 0.5 μ.

(Application Example)
Next, one application example of the humidifier of the present design using hollow fibers will be explained with reference to the figures. Figure 1 is a cross section of the humidifier, with an aperture (1) for the introduction of the gas to be humidified and an aperture (2) for discharge of the humidified gas arranged at either end of a sealed container (5), and an aperture (3) for the introduction of water or an aqueous solution arranged in the central portion. The sealed container (5) preferably can be formed from a transparent resin such as polycarbonate, acryl, or vinyl chloride, and for a cylindrical container the size generally is approximately 8 – 30 cm (an interior volume of approximately 0.2 – 2 l.). This size can be varied according to the size and number of the hollow fibers housed in the container and the desired humidification capacity.

Approximately 4,000 – 10,000 hollow fibers (6) are housed in sealed container (5). Both ends of the bundle (7) of these hollow fibers are anchored in the container by sealing members (8) formed of epoxy resin, for example.

Figure 2 shows another application example of the present design; a U-shaped bundle (7) of a large number of bundled hollow fibers is housed in a sealed container (5) having end apertures (1), (2) and a central portion aperture (3), and the ends of that are anchored in the container by sealing members (8). Because it is sealed in this manner the sealed container (5) is partitioned into three regions; that is, a region (11) that includes the end aperture (1), a region that includes the end aperture (2), and a region (13) that includes the central portion aperture (3).

In Figure 1 and Figure 2, the region (13) that includes the central portion aperture (3) is filled with water or an aqueous solution and the aperture (3) is closed, and when the gas to be humidified is introduced into the end aperture (1) as indicated by the arrow, water vapor permeates the gas in the individual hollow fibers. Consequently, water evaporates into the gas discharged by the humidified air from the aperture (2), and thus the amount of water filling the region (3) of the sealed container (5) is reduced, but the depleted amount can be replenished appropriately from end aperture (3). Furthermore, by connecting the end aperture (3) to another larger water storage tank by means of a tube or the like, the water can be replenished continuously.

As moisture evaporates, the temperature in the region (3) decreases, so when a homothermal humidified gas flow is to be obtained the temperature of the humidifier must be maintained. The temperature can be maintained by heating the humidifier with a publicly known means such as a heat transfer device, an insulating tube, or an infrared heater. Moreover, it is effective to place the humidifier in a homothermal environment. Furthermore, two apertures can be provided in the central portion of sealed container (5), and an external circulation flow channel can be connected to these apertures through a thermostatic water tank to circulate water that is heated to a constant temperature.

Based on experimentation, when dry air (37°C) with a flow rate of 15 l/min was passed through a humidifier for which porous hollow fibers (0.2 m^2) manufactured from polysulfone and having an inner diameter of 220 μ and an outer diameter of 38 μ were housed in a sealed container with a diameter of 3 cm and a length of 10 cm, humidification with an RH of 100% was easily achieved. Furthermore, under the same conditions when dry air was passed through a humidifier housing ethylene vinyl alcohol hollow fibers (0.2 m^2) with an inner diameter of 200 μ and an outer diameter of 280 μ and a permeability of 4.5 ml/mm $Hg{\cdot}m^3{\cdot}hr$, humidification with an RH of 100% was easily achieved.

(Effect of the Design)
As described above, the humidifier of the present design uses hollow fibers, so the configuration is simpler than that of the conventional bubbling method or methods using filter paper or gauze.

Furthermore, if porous hollow fibers with a pore diameter of not more than 02 μ are used as the hollow fibers, bacterial will be completely unable to pass through the walls of the hollow fibers, and a humidified gas that is extremely pure can be obtained. Moreover, if porous hollow fibers with a pore diameter of not more than 100 Å are used, contamination of the gas by pyrogenic substances (pyrogens and the like) also can be prevented.

4. Brief Description of the Figures
Figure 1 and Figure 2 are cross sections of the humidifier of the present design.

1, 2 End aperture
3 Central portion aperture
5 Sealed container
6 Hollow fiber
7 Hollow fiber bundle
8 Sealing member

Fig. 1

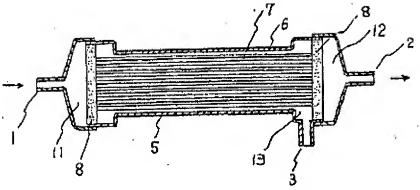

Fig. 2